14 Stories Never Before Published Anywhere

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STAR science fiction stories no. 2

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- Critical Factor

Critical Factor
by Hal Clement

Pentong, excited for the first time in his life, raced northward. There was no need to grope or feel his way; this close to the great earthquake zone there were always minor tremors, and their echoes from the dense basalt below and the emptiness above reached him almost constantly. The treacherous sandstone strata, which beguiled the lazy traveler with the ease of penetration they offered and then led him up to the zones of death, were easy to spot; Pentong actually used them now, for seeing was so good that he could leave them with plenty of time to seek the safer levels below whenever they started to slope.

The worst of his journey was behind. The narrow bridge of livable rock which led to the strange land he had found had been recrossed in safety, in spite of the terrifying and deceptive manner in which temblors from the earthquake zone far to the north were trapped, magnified, and echoed from its sides. Now he could see for many days' travel all about him, and as far as he could see the land was good.

Not as good as that he had visited, of course. This was the land he had known all his life, where food was just hard enough to find to make life interesting; where for ages past counting other, less fortunate, races from the far, far north had sought to break in and kill that they might inherit its plenty; where pools of magma shifted just rapidly enough to trap the unwary between impenetrable basalt and glowing death; where, if Pentong was right in what he believed of his discovery, regions now too close to the zones of death might be made accessible and provide food and living space for unguessable generations to come.

He dreamt of this possibility constantly as he moved. No trace of his passage marked the rock behind him, for none of it was edible; but he hardly thought of food for himself. Speed was his prime concern, and to achieve it he traveled as close as he dared to the upper zones.

The nearest settlement was more than five thousand miles north, he knew; his memory held a sharp picture of the tortuous path he had followed from it, and he retraced that path now. It led him far to the east, where the earth tremors were faint and travel slowed by the poor vision; then back, at a much lower level, to the northwest, where the principal delay was the denser rock. Five hundred miles short of his goal he had to stop, to examine carefully the region of magma pools through which he had passed on his way south. The precise path he

had followed could not now be used; it was blocked in several places by molten rock which had forced its way between strata and heated the otherwise habitable stone above and below to an unbearable degree. But other paths existed; and slowly and carefully Pentong wormed his way between the pools, sometimes retreating the way he had come, sometimes going almost straight away from his goal, but gradually working north and downward until the last of the dangerous pockets of fluid lay behind him. Then he could hasten once more; and at last he reached the bed of carbonate rock, a mile thick and more than thirty thousand square miles in area, which had been deposited on the floor of an ancient sea some hundreds of millions of years before and was now safely surrounded and capped by harder layers which shielded its inhabitants from filtering oxygen. This was the city —not the one where Pentong had been born, but the farthest south of all the dwelling centers of his people, and the one to which the more adventurous spirits of the race tended to gravitate. The cities to the northwest and northeast, under the Bering and Icelandic bridges, held danger, of course; they bore the brunt of the endless defense against the savage tribes from beyond the bridges. Still, that danger was known and almost routine; it was the unknown parts of the world that spelled adventure. Pentong, he was sure, had proved himself the most adventurous so far; and he was also sure that he had done more.

"Halt!" The challenge came through the rock as Pentong's great, liquid body began to filter into the limestone. No city, even this far from the zones of war, dared be without sentries. "Name yourself!"

"I am Pentong, returning from the south, a trip that was commanded. My word is this." He emitted the coded series of temblors which the City Leaders had given him for identification, when and if he returned.

"Wait." The explorer knew that the sentry's body extended far back into the city, and that at his other end he was in communication with the Leaders. The wait was not long. "Enter. You may eat, if you hunger, but go to the Leaders as soon thereafter as may be."

"I am hungry, but I must go to them at once. I have found something of importance, and they must know." The sentry was plainly curious, but forebore to question further; obviously if this stranger felt his news too important to wait for food. he would hardly pause for conversation.

"Take the Stratum of Manganese; it will be cleared for you," was all the watcher said. Pentong acknowledged the courtesy—traffic was sometimes a problem in a city of sixty billion inhabitants, each of whom averaged ten cubic yards in volume and was apt to have that bulk spread through a most irregular outline. The Stratum of Manganese was a foot-thick layer stained with the oxide of that metal,

and thereby marked plainly to Pentong's senses. It was cut off sharply by a fault which extended across the center of the city in a northeast-southwest direction; and at one point along that fault was a large volume where numerous boulders of quartz, probably washed to this spot by some ancient river, were imbedded in the limestone. Here the Leaders, or enough of them to transact business, could always be found. Pentong greeted them, received the acknowledgment, and began his report without preamble.

"About five thousand miles to the south," he said, "the continental mass in which this city is located narrows apparently to a point. The earthquake zone extends to this point, and seeing is good; but echoes tend to be confusing in some regions, and I explored many of these by touch. In one such area I found a long tongue of sandstone extending yet farther south; and after debating whether I should return to report its existence before venturing out along it, I decided it would be better to have something more complete to report. It was almost like traveling through a stratum which has been cut off on opposite sides by parallel dikes; but the sides this time were simply emptiness. There was no zone of death, however, apparently the tongue of rock is surrounded by what Derrell the Thinker called *ocean,* which seems to protect the upper regions of portions of the continents. Below, of course, was basalt.

"The neck of rock went on, seemingly without end. Sometimes it widened, sometimes narrowed so that I thought it had come to an end; but it always went on. Those who claim the continents are drifting will have to explain how that narrow ridge of stone has stayed intact.

"At last, however, it really widened; and to make short a report whose data was long in compiling, there is a continent at the other end—and I could find no trace of other than lower animals in that continent. That, however, is not its most important feature; what is really striking is the fact that it appears to have no Zone of Death whatever. It is covered with a solid material, which seems to be crystalline from the way it carries sound, but which is impenetrable to living bodies. The continent is inhabitable from top to bottom."

"How about edible rock?"

"As good or better than our own land." The Leaders reacted audibly to this, and it was some time before speech was again directed at the explorer. Then, as he had expected, it was complimentary.

"Pentong, you deserve the thanks of every inhabitant of this continent. If your report is as accurate as it seems to be objective, our food problem is solved for generations to come. We will transmit this news to the other cities, and plans for colonizing the new continent will be worked out as rapidly as may be. Your name will be known

from here to the Northern Frontier."

For a moment the explorer basked in the praise that was the deepest need of his kind; then he spoke again, with a delicious thrill of anticipation.

"Leaders, there is yet more, if I may speak." Cracklings of surprise spread from the boulder-shot area, and the nearer citizens paused in their activities to learn what went on.

"Speak."

"I was curious as to the nature of this solid which seemed as impenetrable as basalt, and strove to learn more about it. For a long time I made no progress; but at last I came to an earthquake zone, in which magma had risen very near the upper levels. About this point the strange substance was thinner; and while investigating the neighborhood, a pocket of magma broke through the Outer Void. This I could tell, partly because of the good seeing, and partly because I could feel the heat working down from the thin layers above." He paused.

"This has occurred before," commented one of the Leaders. "What did it teach you?"

"Where the magma spread, the solid disappeared—and *became like the ocean!"* Pentong stopped again, for purely rhetorical reasons—he knew there would be no interruption this time.

"As you all remember, Derrell the Thinker showed that *ocean* was a substance, apparently liquid like magma; he studied its sound-transmitting properties, and described them well. I heard his lecture, and examined the substance myself on several occasions. This crystalline sheath of the Southern Continent is simply solid ocean; it melted just as rock does when the magma reached it." Again the pause, and this time the Leaders conferred briefly.

"Your point is of extreme scientific interest," their spokesman finally said, "but we admit we do not see practical importance for it as yet. We gather from your manner that you do; if you would go on—" he left the sentence unfinished.

"My point is simple. Ocean protects rock from the oxygen, which filters down from the Void and kills those exposed to it—sometimes even renders rock poisonous. Much of our continent is protected by ocean, but much is not, and its upper layers are therefore unattainable. This solid ocean melts very easily, as I could see on the Southern Continent; and the continent seems to be covered with it to a depth of more than a mile, on the average. It may seem an ambitious project, but if that continent were to be heated enough to melt its ocean covering, would not it add to the ocean over the rest of the world and thus *cover more of our continent?"*

For long moments no answer came; Pentong could not tell

whether the Leaders were actually considering the problem objectively or reacting emotionally to his admittedly audacious suggestion. The first response was in the form of a question.

"Just why should this material blanket the continents instead of remaining more or less where it is? You seem to be taking a good deal for granted."

"I realize that the behavior of liquids such as magma and ocean out in the Void is not generally known," responded Pentong. "However, there exists a good deal of observation which strongly suggests that magma, at least, tends to spread out over the surface of the Earth when released to the Void. I admit that further observation would be needed to prove that ocean does the same—but is it not already doing just that? It seems reasonable to suppose that the liquid ocean has spread as far as its quantity permits; if we add more, it should spread farther. Let us at least check this point; I can show the way, or for that matter describe it, to the Southern Continent, and the necessary experiments could be conducted by a small group."

The news of the Pentong project took some time to reach Derrell the Thinker. There were several reasons for this; for one, he was located thousands of miles from the city under the Gulf of Mexico where Pentong had made his report, and for another he was in the midst of a battlefield. The latter fact was not at once evident; the only sights and sounds—the two were identical to Derrell, whose only long-range sense reacted to shock waves in the earth's crust—were those emitted from the earthquake belt to the south and west. He himself was focusing his entire attention on a matter unconnected with the battle; but at least half of his research crew had their fluid bodies extended and joined into a single net that surrounded the entire area of the experiment. It was hoped that none of the savages from the Asian mainland would get through the net without touching one of its strands and betraying their presence.

The thing that interested Derrell was a cave, something almost unheard of in the depths where his people dwelt. Virtually all the empty spaces, which his people regarded asextensions of the Outer Void, were very close to that void; and they were almost without exception filled with the oxygen which poisoned the rocks for the dwellers of the depths. Occasional bubbles occurred in the igneous rocks, of course, filled with gases which had come from the rocks themselves; but as a rule these were unapproachable—the material in which they occurred was nearly impenetrable to the members of Derrell's race, who traveled through rock rather as ink does through a blotter.

The present cave was one of the few exceptions to this rule. The rock itself was not porous enough for travel, but seismic strains had

produced a network of miscroscopic cracks part way into the mass which permitted slow progress, if the traveler had persistence.

Derrell had seen caves before from a distance, but the thing he was watching now had never occurred within his memory or knowledge. The upper level of the bubble was just at the top of the igneous layer in which it had formed; the rock above was sedimentary. Between the two layers a thin sill was gradually making its way from a pool of magma a few miles distant—a pool that was being fed by energy from sources far below, and outside the bounds even of Derrell's knowledge. It was more than likely that some day this sill might grow to the proportions of a laccolith, in view of the nature of the rock above; but this was not the scientist's concern at the moment. The advancing magma was approaching the bubble, and he wanted to see what effect the trapped, high-pressure gas in the "empty" space would have on the molten rock. It was fortunate that this was occurring just here; the endless, tiny seismic shocks from the southwest made things clearly visible throughout the region. It would have been extremely dangerous, with the Asian savages filtering through the neighboring strata, if the investigators had had to produce sounds of their own in order to further their research.

Derrell had a mental picture of what would occur when the molten rock reached the bubble, but like any good scientist he was not allowing it to influence his observing technique. He intended to see everything that happened; and his attention was so completely centered on that particular volume of rock that the arrival of one of his assistants, who had been on a short leave to the nearest of the frontier cities, failed to distract him in the slightest. The assistant himself forbore to interrupt, though he had news that he knew would be of interest; for the magma was very close now to the bubble. Like the chief scientist, the newcomer had a mental picture of the hot fluids simply reaching the cavity, flowing around its walls, and gradually filling it from edge to center. Like Derrell, his idea of the general nature of gases was too sketchy to permit him to realize that, at the very least, the vapor in the bubble must dissolve in the inflowing rock before his picture could be carried through; and like his chief, he had no conception whatever of another force that would also operate. No living member of their race had ever had a good look at a fluid that was not in a confined space; they had never seen a free liquid surface. Their experience was about to be enlarged.

There would be no point in guessing who was the most surprised by what actually happened, but there was no doubt about which of the observers adjusted himself first. Derrell was paralyzed for just an instant as the first drops of fluid reached the opening of the cavity—and *shot straight across it to the other side!*—buthe noted carefully and

precisely how more of the magma followed. The drops became a stream, and gradually a pool of the stuff came into being against the side of the bubble opposite the opening. The sides of the pool not in contact with the walls of the cavity seemed to want to form a plane surface, but the stream that was adding to its volume gave rise to disturbances which spread from the point of impact in all directions *over the surface*—waveswhich none of the watchers had ever seen or imagined, and which held even the sentries' attention to a degree which might have proven disastrous. Not until the bubble had filled completely with molten rock did anyone move, speak, or even think of anything but what was happening a few hundred yards away; and even then most of the team waited for Derrell to express an opinion. He, regarding his assistants as students to be guided by suggestion rather than laymen who might be impressed by spot conclusions, opened his comments with a question.

"Could the ordinary pressure on that liquid account for its behavior?"

"Not completely." The answer came promptly from one of the team.

"Why not? Pressure can force liquid between rock layers, and even into rock pores; why could it not send a stream across a space where there is no resistance?"

"It could, I suppose; but I fail to see how ordinary rock pressure could keep one side of that growing pool flat when the rock was not actually touching it. That would seem to call for some invisible substance pressing on that particular surface—a substance not only invisible, but able to permit the stream of rock to pass toward the new pool but not away from it. I find such a substance hard to imagine."

"So do I. Your objection to rock pressure also seems valid—unless someone else can see a way?" He paused for a fair interval, but if any of the assistants had ideas they were not sufficiently formulated for expression. "It would seem, then, that some force with which we are unfamiliar is involved. That means that all the data anyone may have is possibly relevant. Karpor, list the material you have observed which you think might help."

The student responded at once.

"The igneous rock is largely silicates of magnesium, the stratiform layer next to it mostly calcium carbonate. The bubble is about fifteen feet in diameter, one side almost exactly tangent to the stratiform boundary. The boundary itself is parallel to the Void boundary a mile and a half away. The front edge of the sill was advancing at about six inches an hour, and the sill itself had a thickness of about—"

"All right; good so far. Taless, what else?" Another student took up the list; and the recent arrival forgot his news temporarily in the

intensity of the resulting discussion. By the time he remembered it, a hypothesis had been developed.

"It seems possible," Derrell summed the idea up, "that a force of unknown nature exists, which tends to drive liquids (at least) as far from the Void as they are free to travel. Our single observation is to that effect, anyway. It would seem desirable to find other, more accessible hollows in the deeper rocks, to determine how far from the Void boundary this force extends, and to learn if possible whether other things than liquids are affected."

"I wonder what the existence of such a force—if it does exist—will do to the Pentong project," remarked the newcomer, recalling his news suddenly.

"What is that? Another defense plan?"

"Not exactly." The scientist described Pentong's discovery of the Antarctic Continent, and his account of its covering of solid ocean. "His plan to melt this substance, and thus protect more of the world's rock from the oxygen of the Void, has been favorably received by more than half the City Leaders of the continent, and parties are already under way to examine the Southern Continent more completely," he concluded. A student cut in instantly.

"But if this force exists, and ocean is subject to it as magma is, won't the freshly melted ocean simply spread flat over what is already there, and perhaps hardly protect any more land at all?"

"That seems probable," replied Derrell. "Since such a project will involve a vast expenditure of effort, and very possibly interfere with defense on the frontiers, it now becomes imperative that we check the nature and existence of this force as quickly as possible."

"However, if the available ocean surface is not too large," put in another, "even spreading the new ocean over all of it might permit a considerable increase in the protected areas."

"It might; but unless and until we have some idea of the size of the World inside the Void, and how much of the World is covered by ocean, we cannot afford to take a chance on that possibility. We must search for more bubbles; and this carbonate stratum is in contact with igneous rock over many thousands of square miles, it would seem. Break up into parties of three and start exploring; if you encounter savages, call—there are military personnel not too far behind us. This is important." He turned back to the assistant who had brought the news. "I suppose they plan to do the melting by coaxing magma pools toward the Void boundary, and letting them flow out into contact with this solid ocean."

"That is the general idea. However, they plan to do it not only on the Southern Continent. It was felt that there might be much of this solid ocean on our own continent, which we had never discovered

because we cannot venture near enough to the Void boundary; so every pool we can reach is to be brought into use. The places where light rocks project into the Void probably cannot be reached, but it seems to the planners who investigated the data that all the other regions—more than three quarters of the continent—can easily be coated with melted rock, if it clings to the surface reasonably well."

Derrell glanced back at the bubble. "It should do that, all right," he said, "if our force applies out in the Void as well as in the rock next to it. But that means an even more vast expenditure of effort than I had supposed; they'll be pulling the defenders away from the frontiers until the savages from Asia are fighting the ones from Europe—around our dead bodies. Let's find those bubbles." He joined one of the search teams, worried more about the possible waste of work on an inefficient and probably unproductive effort than about the results of covering most of the American continents with lava. After all, he had never heard of the human race, and probably never would.

There was probably not another spot on the North American continent where his team could have found what they sought so quickly; if other regions existed where a lava flow had extended into a shallow sea, hardened, been buried with such speed under calcareous detritus, and then carried down rapidly enough and steadily enough to develop a thick limestone cap over the hardened lava, they had either been lifted back to the surface where they were unapproachable to Derrell's kind or carried so far down as to be altered completely beyond recognition. Here, however, there were cavities; many of them filled by the limy material that had settled into them and hardened into rock and many just too deep in impenetrable regions of the lava to be attained although they were easily visible, but a fair number both empty and attainable. The water that had once filled them had long since gone into hydrates in the overlying rock, and been replaced by gases from the lava—usually oxides of carbon and sometimes even sulfur. These did not bother the investigators, and it was not long before one of the search teams reported an ideal site for investigation. The group congregated at the spot as quickly as possible, and plans were rapidly made.

There was no magma pool near enough to be "tickled" into action this time; but that did not bother Derrell. He had already seen what molten rock would do in this situation. He rapidly gave orders, and the group of liquid bodies gathered in the limestone just above the bubble and began to—eat. The eating was done in a very careful manner; and gradually a large fragment of limestone was separated from the rest of the formation. It was located directly above the bubble, and when freed from its original matrix rested on the thin silicate layer that formed the roof of the cavity. That layer was seamed

with cracks, microscopic in size, but adequate to the needs of the scientists; their fluid bodies worked inside those cracks, loosening particle after particle, gradually weakening the flimsy roof. The actual force that any one of the beings could exert was minute, lifting a grain of sand would have been impossible for one of the big, but fluid, bodies; but bit by bit the lava moved, as it was dissolved along the tiny zones of weakness the brief exposure to the sea had left.

Toward the end the workers very carefully stayed away from the thin layer, extending only narrow pseudopods to do the remainder of the job. Most of them, in fact, withdrew even farther in order to observe, and two of the assistants completed the final task. Derrell was ready when the lava roof suddenly collapsed, permitting the great block of limestone they had previously freed to drop into the cavern.

No one was very surprised. It behaved, within its limitations, as the magma had done, hurtling against the wall farthest from the Void, and sending a few fragments of its' mass flying off at angles. The fragments also returned to that part of the vast cavity farthest from the broken roof. The force evidently existed; and it appeared to work on solids as well as liquids. Bits of the lava roof had also obeyed the invisible urge; and as far as any one could tell, not a single fragment that was free to move away from the Void had failed to do so.

Without a word, Derrell flowed through the limestone to a point just above the opening. Here he pulled himself into the smallest possible volume, and deliberately began to dissolve the rock about him. He had tried to get to the portion of the bubble where the rocks had come to rest, and found it impossible; the tiny cracks that would have furnished access extended only a foot or two from the surface of the lava. Now he was going to get there—and incidentally, see what effect the new force had on living matter. He learned!

The rock in which he lay broke free as its predecessor had done; and Derrell became the first member of his race to experience the acceleration of gravity. He also was the first to discover that the most noticeable thing about a fall is the sudden stop. The shock did not hurt him—after all, he was accustomed to traveling in regions of seismic strain, and seeing by the resultant shock waves—but the whole thing was slightly surprising. For one thing, the rock had turned over as it fell, and no member of his race had *ever* had a sudden change of orientation with respect to his surroundings. It took several seconds for him to realize that it was he who had moved, not the surrounding universe.

Once convinced of that, he started to emerge from the rock which he had ridden; and in doing so he learned the most painful lesson of all about gravity.

Derrell's body was liquid. It was less dense than water, being

composed mainly of hydrocarbons; it had no more rigidity than water. All its support was normally furnished by the rock in which it happened to be "soaked" at the moment; he moved by controlling the liquid's surface tension, as an amoeba moves—or, for that matter, as a man moves a muscle. Outside the supporting rock, however, he was just a puddle of oil—and once he started out, he was completely unable to stop. The block of limestone he had ridden was not quite at the bottom of the huge cavity; as a portion of his mass emerged, it tended to flow downhill toward the lowest available point; he had the choice of following it or being torn apart, and he liked the latter alternative no better than a more solid organism would. He followed. Five seconds later he was a completely helpless pool of living liquid, in the bottom of a bowl of glassy, impenetrable lava. He could not even raise a ripple on his own surface.

He could still communicate—that lava carried sound perfectly. However, he did not do so intelligently; all his students heard was a series of endlessly repeated warnings to keep clear of empty spaces—to avoid all dealings with the Force—to leave this neighborhood and to let him die, but be sure to carry the warning to the rest of the world—in short, little but hysteria. Had Derrell not been so upset, he would have seen the way out in a moment; but he can hardly be blamed for being perturbed. A man suddenly finding himself imbedded completely in a block of concrete, yet somehow still living and breathing and able to speak, might have had some inkling of the scientist's emotions; but at least a man could vaguely imagine such a situation in advance. No member of Derrell's race could have foreseen any detail of what had happened to him.

Fortunately, the students for the most part remained calm; and it was one of these who saw the solution. Derrell was restored to something like a state of reason when tiny pebbles of limestone began to fall near, and sometimes into his body. It was a long, long, job; but at last the dwellers of the rock completed the task which the ocean had failed to perform a hundred million years before, and the cavern was full of limestone. Even now travel was not easy—the space between particles was too large, and Derrell had acquired a strong antipathy to open spaces; but travel was at least possible, and at long last he found himself once more in habitable, negotiable, comfortable rock outside that terrible cavern. For a long time he rested; and when finally he spoke, it was with conviction.

"Whatever we may learn of that force in the future, certainly no one can ever doubt its reality. I hope none of you ever feel it. Those of you who were over that cave releasing rocks that enabled me to escape were taking a chance worse than that ever faced by soldier or explorer; believe me when I say I am grateful.

"One point we have learned, besides the mere existence of the force: it is not always perpendicular to the Void boundary." A faint flicker of surprise manifested itself among the listeners, but stilled at once as they perceived that the scientist was right—the boundary was extremely irregular where it passed nearest this region; projections of rock reached out into the Void at frequent intervals sometimes for more than a mile. There was no single direction that could be said to be perpendicular to it.

"That leaves two principal possibilities. One is that the force is directed at least somewhat at random, and the ocean has collected in specific localities because of that fact. If that is so, then the Pentong project is useless; the new ocean will simply add to the old, and cover no more Earth. The other main possibility would seem to be that the force does not extend into the Void at all; and in that case we have no idea at all what will happen, except that the magma we bring up will probably spread over the boundary as it always has. We cannot even guess what the melted ocean will do.

"It seems to me a very ill-advised plan, to divert as much effort as this project would demand from our defense, when we cannot even be moderately sure of success. I think I will go to the nearest city to express my opinion—there is still too much risk from the tribes of Asia to take any chances. Has anyone a different opinion, or a better plan?"

"One thing might be done first." It was Taless, one of most self-confident of the group. "It seems almost as bad to halt the project for ignorance as to waste effort from the same cause. I would strongly recommend that we learn something about the force beyond the boundary before we express opinions to any City Leaders. At the most, let us advise delaying, not canceling, the project until some data on that matter can be obtained."

"And how would you secure this data?"

"I do not know; but we have a team of presumably competent researchers here. I certainly would not regard such investigation as hopeless, without at least some effort being made."

"The data would have to be extremely precise, and sufficient in amount to be completely convincing; the matter is vitally important for the future of our people everywhere."

"I realize that. What is new about requiring precision in measurement?"

Derrell pondered briefly. "You are right, of course," he finally said. "We will advise *postponing* the Pentong project. Two of you can carry that message to the city. The rest of us will start devising ways to learn whether or not melted ocean will spread over the surface of Earth. If we find that it does, we coat the American continents with lava; if not, the magma pockets can stay where they are. Suggestions

for experimental techniques are now in order.”